



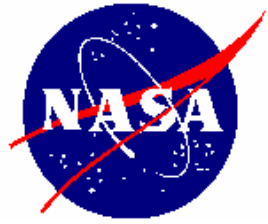
NPR 8705.5

Probabilistic Risk Assessment (PRA)

Procedures for

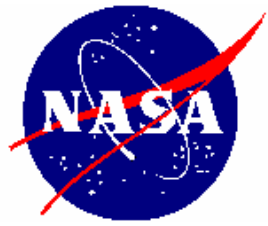
NASA Programs and Projects

Peter G. Prassinos, NASA/HQ/OSMA
PRA Exchange of Information (PRAXI-5)
ATC, Cleveland, OH
October 28-29, 2004



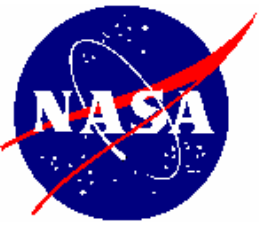
Objectives

- Supports the implementation of structured Risk Management (RM) as stated in NPR 8700.1, *NASA Policy for Safety and Mission Success*
- Provides both qualitative and quantitative results regarding weaknesses and vulnerabilities in systems that can adversely impact safety, performance, and mission success.
- Provides insights into viable RM strategies by supporting optimal decisions with respect to the expenditure of resources.



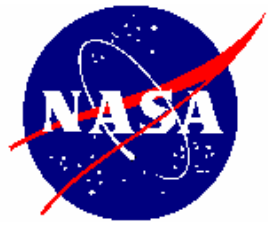
Purpose of NPR 8705.5

- **Provides basic requirements for performing a probabilistic risk assessment (PRA) for a NASA program or project.**
- **A companion document is the Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners (<http://www.hq.nasa.gov/office/codeq/doctree/praguide.pdf>)**
- **Addresses technical and safety risk and does not address programmatic risk involving consideration of cost and schedule.**



Applicability

- **Programs/projects that provide aerospace products or capabilities; i.e., space and aeronautical systems, flight and ground systems, technology demonstration / validation, and operations**
- **Not required for other projects; i.e., research, training, or education**
- **Applicability to programs/projects in progress will be made on a case-by-case basis and approved by the Governing Program Management Committee**



Level of the PRA

The importance and scope of the project or program being assessed is used to identify the extent of the risk assessment application.

- Potential affects on the public, crew, workers, strategic importance, value and schedule**
- Full-scope, Limited-scope and Simplified**



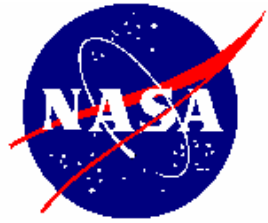
When to USE PRA: Criteria for Selecting the Scope of a Probabilistic Risk Assessment (PRA)

CONSEQUENCE CATEGORY	CRITERIA / SPECIFICS		NASA PROGRAM/PROJECT (Classes and/or Examples)	PRA SCOPE
Human Safety and Health	Public Safety	Planetary Protection Program Requirement	Mars Sample Return Missions	F
		White House Approval (PD/NSC-25)	Nuclear Payloads (e.g., Cassini, Ulysses, Mars 2003)	F
		Space Missions with Flight Termination Systems	Launch Vehicles	F
	Human Space Flight		International Space Station	F
			Space Shuttle	F
			Human Space Experiments	F
			Project Constellation	F
Mission Success (for non-human rated missions)	High Strategic Importance / High Value Strategic Property / High Cost Projects		Mars Programs	F
	High Schedule Criticality		Launch Window (e.g., planetary missions)	F
	All Other Missions		Earth Science Missions(e.g., EOS, QUICKSCAT, specific payloads)	L/S
			Space Science Missions (e.g., SIM, HESSI, specific payloads)	L/S
			Technology Demonstration / Validation (e.g., EO-1, Deep Space 1)	L/S
			Medium to Low Cost Projects	L/S

***Key:**

F – Full scope PRA.

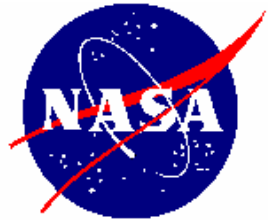
L/S – Limited-scope or simplified PRA should be performed or altogether waived, at the direction of the program/project.



Full Scope PRA

A Full-scope PRA supports risk management for projects involving complex systems in high-stakes programmatic contexts:

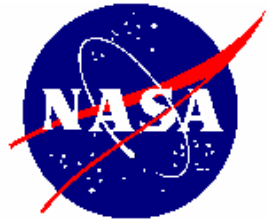
- Addresses all applicable scenarios and end states that lead to failure to meet safety and mission objectives.**
- Includes a complete uncertainty analysis to provide the overall degree of uncertainty in results and an understanding of the critical sources of uncertainty.**



Limited-Scope PRA

Limited-Scope PRA focuses on specific mission-related end states of interest, instead of all applicable end states

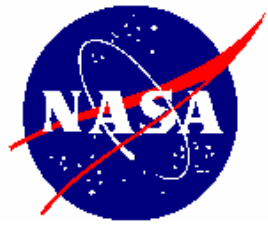
- **The scope is defined so that the results can provide specific answers to pre-identified mission-critical safety concerns**
- **Sources of uncertainties that have a strong effect on the results and their insights are identified and quantified**



Simplified PRA

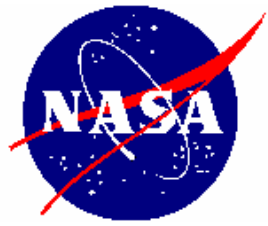
Simplified PRA identifies and quantifies major mission risk contributors (to all end states of interest)

- **Generally applies to systems of lesser technological complexity or systems having less available design data.**
- **Reduced set of scenarios or simplified scenarios designed to capture essential, top level, mission risk contributors.**
- **Sources of uncertainties that have major effects on results are identified and, in cases where they affect management decisions, shall be quantified**



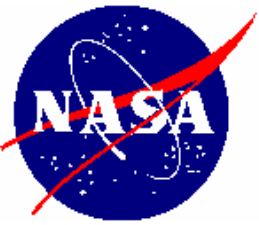
Documenting PRA Decisions

- **Program/Project Manager documents PRA level and basis in risk management plan**
- **Program/Project Manager brief GPMC during formulation phase**
- **Disputes concerning PRA decisions and level shall be elevated to the next level of PMC**



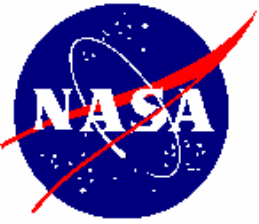
Implementation Responsibilities

NASA shall, through prudent hiring, professional development, and mentoring, increase and maintain its capability to conduct, understand, and use PRA in support of a program/project life cycle



Implementation Responsibilities

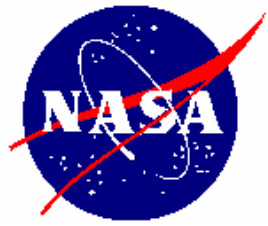
- **Office of Safety and Mission Assurance will maintain best available PRA methods, practices, applications, software, and standards:**
 - **Develop, coordinate, publish, disseminate, explain, interpret, and maintain NASA PRA policy, procedures, criteria and guidelines and assure implementation**
 - **Provide corporate and functional leadership in PRA related information, applications and methodology**
 - **Organize and coordinate peer reviews of PRAs**



Implementation Responsibilities

Associate Administrators and Mission Directorates are responsible for assuring that RM policies, plans, techniques, procedures, and standards are implemented:

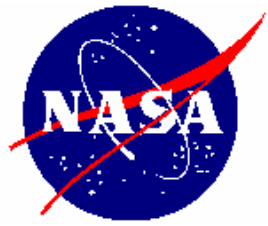
- Appropriate resources available for the PRA**
- Technical quality throughout PRA efforts**
- PRA results communicated to appropriate personnel**
- PRA awareness and training for managers and practitioners**
- PRA requirements are implemented on contracts**



Implementation Responsibilities

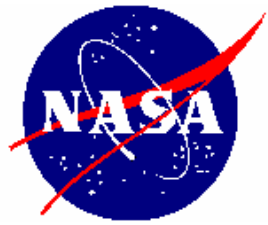
Center Directors shall:

- Ensure that their organizations acquire and maintain PRA expertise necessary to support Center-based programs/projects**
- Assist Center-based programs/projects in conducting required PRAs; i.e., provide required resources, training, tools, technical advice, or assistance in obtaining competent support services**



Implementation Responsibilities

- **Program/Project Managers:**
 - **Conduct and use PRA to support risk management decisions**
 - **Document PRA plans in the risk management plan**
 - **Brief the GPMC on PRA decisions and rationale during the formulation phase of the program or project**
 - **Maintain and safeguard PRA records (NPR 1441.1, NASA Record Retention Schedule)**
 - **Clearly communicate PRA results and insights**
 - **Update management plans to reflect insights from PRA**
 - **Consider modifying the project through design, operation, and maintenance upgrades if the residual risk is deemed unacceptable**



PRA Process

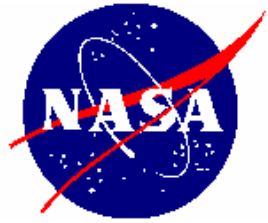
- **PRA characterizes:**
 - (1) What can go wrong? (2) How likely is it? (3) What are the consequences?
- **A typical scenario-based PRA involves:**
 - Definition of objective*
 - System familiarization
 - Identification of initiating events*
 - Scenario modeling*
 - Failure modeling*
 - Quantification*
 - Uncertainty analysis*
 - Sensitivity analysis
 - Importance ranking
 - Data analysis*

* - Required Elements



PRA Implementation

- **Scope of the PRA is commensurate with objectives, complexity of the system, and severity of the consequences**
- **Use consistent defined terminology (with that used in the program/project)**
- **Identifies the elements of risk (initiators, hazards, scenarios, probabilities, consequences and uncertainties)**
- **Uses analytical method and techniques consistent with the systems being analyzed**
- **Uses existing generic and specific data**
- **Has periodic in process reviews**



PRA Team

- **Multi-disciplinary team representing key functional elements (design, operation, safety, maintenance) and organizations**
- **Team has training and experience in the development of a PRA and the application of PRA methods, techniques and models.**
- **Considers impacts of inter- and intra-project or mission dependencies**
- **Uses insights from crew, ground personnel, and workers to develop an objective “un-biased” model.**



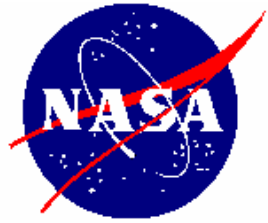
PRA Development

- **A PRA expert shall serve as the PRA Technical Authority on programs/projects, with technical PRA decision-making authority**
 - **Selection of the PRA Technical Authority shall be made with guidance from the Center SMA or HQ SMA organization**
- **A PRA shall follow quality assurance principles and practices that are analogous to those in other engineering fields and practices**
 - **Suitable team**
 - **Proven methods and computer codes**
 - **Documented assumptions and ground rules**
 - **Use of appropriate engineering and reliability data**
 - **Internal Review**
 - **Communication**



Independent Peer Reviews

- **An independent peer review shall be conducted for all full-scope PRA**
 - **Concentrate on the appropriateness of methods, information, sources, judgments, and assumptions as well as the application and results**
 - **A participatory peer review that proceeds in parallel with the PRA should be considered**



PRA Application

- **A PRA shall be comprehensive, balanced, and tailored**
 - **Considers complete environment and all factor that pertain to system being assessed**
 - **Scope considers issues of safety, operation and mission assurance, is commensurate to the level of risk and is timely for risk management decisions**
 - **Level of detail is proportional to PRA scope and objectives, and system complexity and hazards.**
- **PRA used as a “Living Tool” to facility continuous risk management**
- **A PRA shall consider all life cycle phases**
 - **Design**
 - **Operation**
 - **Upgrade**
 - **End-of-life/Decommissioning**